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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
H04B 7/06

A1

(11) International Publication Number: WO 00/11806

(43) International Publication Date: 2 March 2000 (02.03.00)

(21) International Application Number: PCT/US99/18952

(22) International Filing Date: 24 August 1999 (24.08.99)

(30) Priority Data:
09/139,370 25 August 1998 (25.08.98) US

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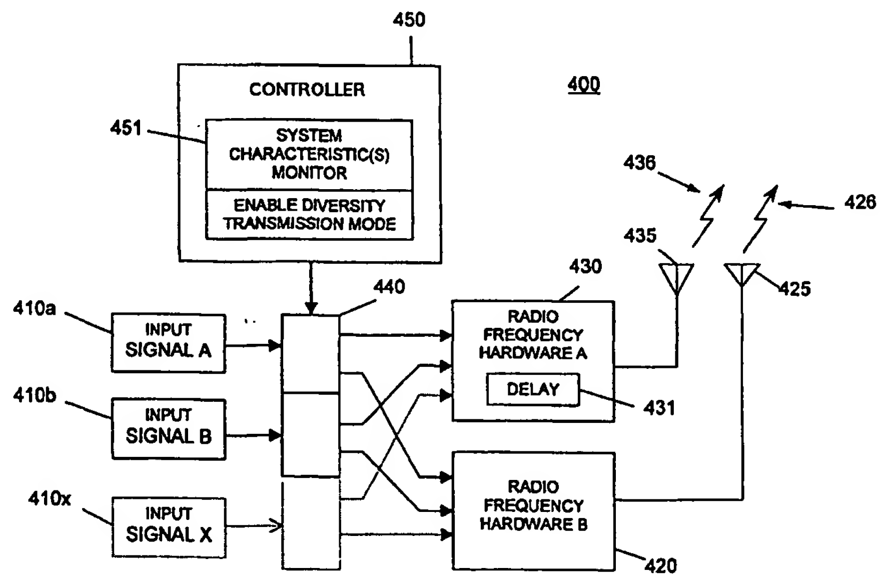
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: WIRELESS COMMUNICATIONS SYSTEM EMPLOYING SELECTIVE DIVERSITY TRANSMISSION, METHOD FOR SELECTIVELY ENABLING DIVERSITY TRANSMISSION, AND A WIRELESS TELECOMMUNICATIONS NETWORK EMPLOYING THE SYSTEM OR THE METHOD

(57) Abstract



A wireless communications system for transmitting an input signal to a remote receiver, wherein the wireless communications system includes: a first transmitter that receives the input signal and generates a first radio frequency signal; a second transmitter having a delay associated therewith; and a diversity transmission mode controller that selectively couples the input signal to the second transmitter as a function of at least one characteristic of the system, the second transmitter generating a second radio frequency signal that is delayed relative to the first radio frequency signal. The remote receiver is preferably capable of simultaneously receiving and processing the first and second radio frequency signals whereby the transmission quality of the system is enhanced. Various characteristics of the system can be used, individually or in combination, to trigger the selective enablement of the diversity transmission mode, including: the transmission bit error rate associated with the first radio frequency signal; the received signal strength at the remote receiver associated with the first radio frequency signal; a timing advance parameter of the remote receiver; the number of remote receivers that simultaneous receive service from the system; and a subscriber class of the remote receiver.

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WIRELESS COMMUNICATIONS SYSTEM EMPLOYING SELECTIVE DIVERSITY TRANSMISSION, METHOD FOR SELECTIVELY ENABLING DIVERSITY TRANSMISSION, AND A WIRELESS TELECOMMUNICATIONS NETWORK EMPLOYING THE SYSTEM OR THE METHOD

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to wireless communications systems and, more specifically, to a wireless communications system employing selective diversity transmission, a method of enabling selective diversity transmission, and a wireless telecommunications network that employs the system or the method.

BACKGROUND OF THE INVENTION

In conventional cellular telecommunication systems, radio communication occurs between fixed equipment at a base station, or "cell site," and mobile units, or "remote receivers," travelling within the cell. The signal path from the cell site to the remote receivers is typically referred to as the "forward" path, while the signal path from a remote receiver to the cell site is typically referred to as the "reverse" path. One of the limitations of cellular system performance is the capability of remote receivers to receive information in the presence of interference that affects the forward path signal. The key performance measure is the minimum ratio of signal power to interference power, or "signal-to-noise ratio," that permits acceptable communication quality. In the presence of interference, the bit error rate (BER) associated with the information contained in a received signal increases; as the bit error rate (BER) associated with the forward path increases, and/or the signal strength

decreases, the quality of the communications system from the perspective of a remote receiver becomes degraded.

In accordance with Telecommunications Industry Association (TIA) standards, an equalizer is required to be integrated into the circuitry of a remote receiver. The equalizer must be capable of operating well when receiving signals through two distinct paths separated in time by up to a symbol duration. The purpose of the equalizer is to mitigate the effects of delay spread as it arises in the transmission environment of cellular telephones; delay spread is the period over which a signal transmitted at an instant is spread over time by the communication channel.

For appropriate equalizer architectures, excellent remote receiver performance can be achieved if the channel exhibits particular characteristics. Specifically, a conventional equalizer will perform very well when the channel appears to have consisted of two paths of equal average power, separated in time by a symbol duration. This improved performance results from a combination of two factors: the diversity between the two paths (*i.e.*, the low probability that the two signal paths will fade simultaneously relative to the individual probabilities of fading), and the minimal level of Inter-Symbol Interference (ISI) that occurs when the paths are separated by exactly a symbol duration. In typical operating environments, it is possible that paths with the desired characteristics will occur naturally. Unfortunately, however, such circumstances rarely arise, and delay spreads are typically negligible in comparison to the symbol duration. Improved receiver performance can be achieved, however, by transmitting two forward path signals, delayed in time

by up to a symbol duration, to simulate the effect of delay spread; this transmission technique is known as "diversity transmission."

United States Patent No. 5,574,989 to Watson, *et al.*, ("Watson") describes a method of employing base station diversity transmission to enhance the forward path performance, or transmission quality, of a cellular system. Although the system described by Watson can be used to advantage to improve the forward path performance, the system always employs diversity transmission. Because diversity transmission requires two transmitters for every forward path signal, the continuous use of diversity transmission undesirably decreases the number of remote receivers than can be simultaneously serviced by a cell site. Furthermore, diversity transmission may not always be necessary to achieve acceptable system performance; thus, its continuous use is a waste of system resources and electrical power.

SUMMARY OF THE INVENTION

To address the above-discussed deficiencies of the prior art, the present invention relates to a wireless communications system employing selective diversity transmission, a method of enabling selective diversity transmission, and a wireless telecommunications network that employs the system or the method.

In one embodiment, a wireless communications system employing the principles of the invention includes: a first transmitter that receives an input signal and generates a first radio frequency signal; a second transmitter having a delay associated therewith; and a diversity transmission mode controller that selectively couples the input signal to the second transmitter as a function of at least one characteristic of the system. The second transmitter generates a second radio frequency signal that is delayed relative to the first radio frequency signal. A remote receiver is preferably capable of simultaneously receiving and processing the first and second radio frequency signals whereby the transmission quality of the system is enhanced. Various characteristics of the system can be used, individually or in combination, to trigger the selective enablement of the diversity transmission mode, including: the transmission bit error rate (BER) associated with the first radio frequency signal; the received signal strength (RSS) at the remote receiver associated with the first radio frequency signal; a timing advance parameter of the remote receiver; the number of remote receivers that simultaneously receive service from the system ("system load"); and a subscriber class of the remote receiver.

The present invention therefore provides a selectively-enabled diversity transmission mode in a wireless communications system. Instead of always

(or never) providing diversity transmission, the present invention enables diversity transmission as a function of one or more system characteristics, such as the BER associated with a radio frequency signal received by a remote receiver; *e.g.*, if the BER associated with only transmitting a single signal exceeds a predetermined value, then the diversity transmission mode controller preferably enables the diversity transmission mode to decrease the BER. Alternatively, the RSS at the remote receiver can be used to trigger the enablement of diversity transmission; *e.g.*, if the RSS associated with only transmitting a single signal is less than a predetermined value, then the diversity transmission mode controller preferably enables the diversity transmission mode. Still further, a timing advance parameter of the remote receiver, the system load, and/or a subscriber class of the remote receiver can also be used to trigger the enablement of diversity transmission. Any system characteristic, or parameter, can be used, individually or in combination with one or more other system characteristics, to trigger the enablement of diversity transmission; *e.g.*, if the BER exceeds a predetermined value *and* the system load is less than a predetermined threshold, then the diversity transmission mode controller preferably enables the diversity transmission mode. By dynamically enabling diversity transmission as a function of a system characteristic, such as decreased system performance, the availability of system resources optimized.

The foregoing has outlined, rather broadly, the principles of the present invention so that those skilled in the art may better understand the detailed description of the exemplary embodiments that follow. Those skilled in the art should appreciate that they can readily use the disclosed conception and

exemplary embodiments as a basis for designing or modifying other structures and methods for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates a simplified block diagram of a diversity transmission system;

FIGURE 2 illustrates a simplified block diagram of a remote receiver capable of receiving and processing signals transmitted by the diversity transmission system illustrated in FIGURE 1;

FIGURE 3 illustrates exemplary plots of bit error rate (BER) versus signal-to-noise ratio (SNR) for normal and diversity transmission modes;

FIGURE 4 illustrates a functional schematic of an exemplary wireless communications system employing the selective diversity transmission principles of the present invention;

FIGURE 5 illustrates an exemplary method for selectively enabling diversity transmission in a wireless communications system; and

FIGURE 6 illustrates an exemplary telecommunications network in which the selective diversity transmission principles of the present invention may be employed to advantage.

DETAILED DESCRIPTION

In order to better understand the features and advantages of the present invention, a conventional diversity transmission scheme with which the present invention can be employed is first described. Referring to FIGURE 1, illustrated is a simplified block diagram of an exemplary diversity transmission system 100. The diversity transmission system 100 is based on the system and method of employing base station diversity transmission to enhance the forward path performance of a cellular system as described in United States Patent No. 5,574,989 to Watson, *et al.*, ("Watson"); a diversity transmission scheme, however, can be employed to advantage in other cellular, or non-cellular, wireless communications systems.

In a diversity transmission system, an input signal 110 is selected for transmission and, at a desired point in the transmission circuitry, is directed into two paths. In some systems, the input signal division is done while the signal is at low frequencies, while in other systems signal division can be performed at an upconverted frequency level, such as the radio frequency level. As shown in FIGURE 1, the input signal 110 is coupled to first radio frequency hardware 120 for upconversion to radio frequency, power amplification and transmission from an antenna 125. In addition, the input signal 110 is applied to second radio frequency hardware 130, having a time delay circuit 131 associated therewith, for upconversion to radio frequency, power amplification and transmission from an antenna 135. The time delay circuit 131 can operate with a fixed time delay or with a selectable variable time delay up to the symbol duration corresponding to symbols to be transmitted by the system 100. By creating artificial delay spread, the total delay spread may exceed the

capabilities of an equalizer in a remote receiver, d scribed with reference to FIGURE 2, in areas where significant "natural" delay spread exists. To mitigate the degradation associated with this problem, control over the extent of the introduced delay spread may be employed; *e.g.*, a cell site may be configured with a time delay specifically selected for local conditions.

The antenna 135 can be suitably located in spaced relation on the same tower as the antenna 125; alternatively, separate towers can be provided for the antennas 125 and 135. Generally, in accordance with the principles of diversity transmission, time spaced signals 126 and 136 are transmitted to achieve relatively good independence between the signal transmission paths; *i.e.*, to achieve relatively good signal diversity based on transmitted signals with preselected time separation and transmission path independence.

To achieve transmission path independence, the signals 126 and 136 are transmitted to traverse different paths to a remote receiver. Path independence can be achieved by transmitting the signals 126 and 136 through physically separated antennas 125 and 135, as described above, or by an appropriate electronic, or other, technique, such as polarization variation. In this manner, the signal 126 and the signal 136, which is delayed relative to signal 126, are transmitted as diversity signals with intentionally structured time separation to a remote receiver, described with reference to FIGURE 2, in the station reception area.

Referring now to FIGURE 2, illustrated is a simplified block diagram of a remote receiver 200 capable of receiving and processing signals 126 and 136 transmitted by the diversity transmission system 100 illustrated in FIGURE 1. The transmitted signals 126 and 136 are both received by an antenna 210 as

received signals 226 and 236, which are typically slightly different from the transmitted signals 126 and 136 due to channel conditions. The received signals 226 and 236 are directed to receiver hardware 220. The receiver hardware 220 conventionally includes radio frequency (RF) circuitry 221 to separate and downconvert the received signals 226 and 236 for application to intermediate frequency (IF) hardware 222, which demodulates the signals. The demodulated signals are coupled to an equalizer 230.

The equalizer 230 can be, for example, a maximum likelihood sequential estimator that conventionally operates on diversity signals that are delayed by natural channel conditions. Equalizer performance improves the quality of reception through reduction of error rates when there are two uncorrelated, time-separated fading paths, and especially when the delay between the paths is a symbol duration. In accordance with the principles of diversity transmission, the equalizer 230 also is intended to operate on diversity signals that are intentionally time separated (*i.e.*, separated by an artificially imposed delay spread) relative to each other prior to transmission, as described with reference to FIGURE 1. The equalizer 230 resolves the artificially imposed delay spread by first separating the two independent fading signals summed at the receiving antenna 210 and then optimally combining the signals in a manner like that applied to diversity signals that are delayed by natural channel conditions.

After equalization, conventional signal processing circuitry can be used to decode the equalized, received signals 226 and 236. For example, if the input signal 110 is a voice signal, a decoder 240, such as a forward error correcting (FEC) decoder, and a vocoder 250 can be used to decode and

convert the signal to an analog signal that is coupled to an audio speaker 260. If the input signal 110 comprises digital data, other conventional signal processing circuitry can be used to decode the data for use by a digital system coupled to the equalizer 230. Thus, diversity transmission can be used for the transmission of both voice and data, whereby remote receiver performance is improved through an artificial creation of two time-separated signal paths from a transmitting station.

Referring now to FIGURE 3, illustrated are exemplary plots of bit error rate (BER) versus signal-to-noise ratio (SNR) for normal and diversity transmission modes 310 and 320, respectively. As can be seen from the plots 310 and 320, the BER is always less when diversity transmission is used. In typical wireless communications systems, voice quality is acceptable when the channel BER is less than or equal to about 3%. As shown in FIGURE 3, the gain associated with using diversity transmission is about 3 dB at a channel BER of 3%. Conversely, with 3 dB less signal-to-noise ratio, a system using diversity transmission can achieve the same BER performance as a system using only a conventional, or "normal," transmission scheme. As the SNR is increased, the performance advantage of using diversity transmission becomes even greater, as shown by the greater decrease in BER for the diversity transmission mode 320.

Turning now to FIGURE 4, illustrated is an functional schematic of an exemplary wireless communications system 400 employing the selective diversity transmission principles of the present invention. The system 400 includes first radio frequency hardware 420, and second radio frequency hardware 430 having a time delay circuit 431 associated therewith. The radio

frequency hardware 420 and 430 each include multiple "channels" for receiving multiple input signals for upconversion to radio frequency, power amplification and transmission from antennas 425 and 435, respectively. As described with reference to FIGURE 1, the time delay circuit 431 can operate with a fixed time delay or with a selectable variable time delay up to the symbol duration corresponding to symbols to be transmitted by the system 400.

The antenna 435 can be suitably located in spaced relation on the same tower as the antenna 425; alternatively, separate towers can be provided for the antennas 425 and 435. Generally, in accordance with the principles of diversity transmission, time spaced signals 426 and 436 are transmitted to achieve relatively good independence between the signal transmission paths; *i.e.*, to achieve relatively good signal diversity based on transmitted signals with preselected time separation and transmission path independence.

The system 400 further includes a multiplexer circuit 440 for receiving multiple input signals, for example input signals 410a, 410b and 410x, and coupling each signal to one or both of the first and second radio frequency hardware 420, 430. If diversity transmission is not enabled, a signal is only coupled to one of the radio frequency hardware 420, 430. It should be noted that an input signal can be transmitted using only radio frequency hardware 430, which includes time delay circuit 431; in such case, a remote receiver will receive and process the time-delayed signal as a normal signal without the benefits of diversity transmission. When it is desired for a signal to be transmitted using diversity transmission, however, the signal must be coupled to both the first and second radio frequency hardware 420, 430. Selecting a signal for diversity transmission, however, reduces the channel capacity of the

system 400. For example, if it is assumed that radio frequency hardware 420 and 430 each have three channels, then there are a total of six transmission channels. Because the diversity transmission of one signal requires one channel from each of the radio frequency hardware 420, 430, then a maximum of three input signals could be selected for diversity transmission. If only one input signal is selected for diversity transmission, however, the system can transmit an additional four input signals using conventional (*i.e.*, non-diversity) transmission.

To selectively-control the enablement of diversity transmission, the system 400 further includes a controller 450. The controller 450 includes a system characteristic(s) monitor 451 that determines one or more "characteristics" of the system 400; as used herein, a system "characteristic" is defined to include any measurable parameter related to the transmission performance of the system 400, a capability of a remote receiver, or a class of service associated with a remote receiver or system user. The controller 450 is coupled to the multiplexer 440 and directs the multiplexer to couple an input signal to one or both of the radio frequency hardware 420, 430 as a function of one or more characteristics associated with the system 400 or the remote receiver (or system user) to which the input signal is to be transmitted.

Instead of always (or never) providing diversity transmission, a system employing the principles of the present invention will enable diversity transmission for each input signal as a function of one or more system characteristics, such as an average transmission bit error rate (BER); *e.g.*, if the BER associated with only transmitting a single signal exceeds a predetermined value, then the diversity transmission mode controller preferably dynamically

couples the input signal to both of the radio frequency hardware 420, 430. Alternatively, the received signal strength (RSS) at a remote receiver can be used to trigger the enablement of diversity transmission; *e.g.*, if the RSS associated with only transmitting a single signal is less than a predetermined value, then the diversity transmission mode controller preferably dynamically enables the diversity transmission mode for the input signal to be transmitted to that remote receiver. Still further, a timing advance parameter of a remote receiver, the system load, and/or a subscriber class of the remote receiver can also be used to trigger the enablement of diversity transmission. Any system characteristic can be used, individually or in combination with one or more other system characteristics, to trigger the enablement of diversity transmission; *e.g.*, if the BER exceeds a predetermined value *and* the system load is less than a predetermined threshold, then the diversity transmission mode controller preferably enables the diversity transmission mode.

Referring now to FIGURE 5, illustrated is an exemplary method 500 for selectively enabling diversity transmission in a wireless communications system. The exemplary method 500 is preferably implemented as a software-definable process executable within the hardware of a general, or special, purpose computer; alternatively, the process 500 can be implemented in hardware, including embedded software (*i.e.*, firmware). The method 500 is initiated in a first Step 510, which may include receiving input from a system operator as to which system characteristic(s) are to be monitored and the algorithms or threshold values to be used in determining whether to enable the diversity transmission mode. In a Step 520, one or more system characteristics, such as BER or RSS, are monitored. In a Step 530, it is

determined whether the one or more system characteristics ar , for xample, less than, greater than, or equal to some predetermined value(s); this step may include one or more algorithms, such as Boolean functions, that receive the value of one or more system characteristics as input. The result of Step 530 is preferably a "yes" or "no;" *e.g.*, a "yes" result indicates that diversity transmission mode should be enabled in a Step 540. Regardless of the result produced in Step 530, the method 500 continues in a closed-loop fashion, continually monitoring one or more system characteristic(s) in Step 520 and enabling diversity transmission mode in Step 540 as a function of a result produced in Step 530.

Several examples can be used to illustrate the type of algorithm that can be employed in Step 530; the invention is not limited to the exemplary algorithms, however, and those skilled in the art will conceive of various alternative algorithms that can be employed to advantage in specific operating environments. In each example, "L_Threshold" is a value for the load (*e.g.*, the number of simultaneous users) on the cell site, and "Q_Threshold" is a BER value which represents the average call quality in the cell. In each example, once the load falls below L_Threshold, at least one transceiver (TRX) in the cell is deemed to be available for diversity transmission; similarly, the value of Q_Threshold can be used trigger diversity transmission if the call quality in the cell is deemed unsatisfactory. The load and call quality criteria can be used in combination to trigger the activation of diversity transmission; *e.g.*, using Boolean AND or OR functions. In order to avoid rapid changes in transmission modes, it may also be desirable to employ timing filters or hysteresis

parameters to control the selective enabling, and disabling, of diversity transmission.

In a first example, the L_Threshold is set to 50%, the Q_Threshold is set to 3%, and a logical OR operation is selected. The channel resource usage during peak hours is averaged over a short filter length and found to be high (*e.g.*, 90%) and the average BER in the cell is determined to be relatively good (*e.g.*, 2%). Because the channel resource usage is high, it is undesirable to enable diversity transmission, which would reduce the number of users that could simultaneous receive service from the cell. During off-peak hours, however, the channel resource usage drops below 50%, while the BER remains the same. Because the load has dropped below L_Threshold, and because an OR operation was selected, diversity transmission is enabled, which will most likely result in a reduction in the average BER.

In a second example, the L_Threshold is set to 60%, the Q_Threshold is set to 4%, and a logical AND operation is selected. The channel resource usage during peak hours is averaged over a short filter length and found to be high (*e.g.*, 80%) and the average BER in the cell is determined to be relatively poor (*e.g.*, 6%). Although the use of diversity transmission is desirable to improve the poor BER, it will not be enabled because the channel usage is greater than L_Threshold and, thus, the result of the logical AND operation is "false." During off-peak hours, however, the channel usage drops to 55%, which is below L_Threshold; thus, if the BER remains at 6%, or any level greater than Q_Threshold, diversity transmission would be enabled because the result of the logical AND operation would be "true." The enabling of diversity transmission would improve the poor BER without a sacrifice in

system availability since the low channel usag means that there are unused system resources (*i.e.*, TRXs) available.

Finally, FIGURE 6 illustrates an exemplary telecommunications network 600 in which the selective diversity transmission principles of the present invention may be employed to advantage. The architecture of network 600 is functionally equivalent to the conventional architecture defined by standards for the Global System for Mobile (GSM) Communications; see, for example, *General Description of a GSM Public Land Mobile Network* (PLMN); GSM 01.02, Oct. 1993, Version 4.02.

The network 600 includes a Mobile-services Switching Center (MSC) 610 that coordinates and sets up calls to and from multiple remote, or mobile, receivers 200 (one shown). Calls can be routed to the MSC from a Public Switched Telephone Network (PSTN) 660, which includes a plurality of conventional telephones 665 (one shown). The MSC is coupled to a Base Station Controller (BSC) 650, which manages the radio interfaces in a plurality of Base Transceiver Stations (BTSs), generally designated 620, through the allocation, release and handover of radio channels. The BTSs 620, or cell sites, which comprise the radio transmission and reception devices, manage the signal processing related to the radio interfaces. The network 600 also includes a Home Location Resource 670 that stores information related to each remote receiver 200, such as subscriber class information.

Each BTS 620 includes a Distribution Unit (DXU) 640, analogous to the multiplexer 440 described with reference to FIGURE 4, and multiple transceivers (TRXs), generally designated 630, which are each coupled to an antenna, generally designated 635. The TRXs 630 each include a delay circuit

(not shown), analogous to the delay circuit 431 described with reference to FIGURE 4. The interface betw en the BSC 650 and each BTS 620 is typically a T-1 line that includes multiple voice channels as well as a control channel. The control channel routes control signals to a BTS 620 to configure the DXU 640 and TRXs 630.

The conventional GSM architecture of network 600 can be readily adapted to implement the principles of the present invention, without the need for any additional hardware. For example, a conventional BSC 650 includes computer resources that execute software processes to control the operation of BSs 620; the same computer resources can be programmed to execute the method 500, described above, to provide selective diversity transmission. The control channel of the T-1 interface between the BSC 650 and BS 620 can be used to send appropriate configuration information to the DXU 640 to couple one or more voice channels to two TRXs 630, as well as sending a signal to each TRX 630 to enable or disable its delay circuitry and adjust the amount of delay to be applied to a particular signal.

The system characteristics used to control the enablement of diversity transmission are acquired by the BSC 650 from various sources. For example, a remote receiver 200 periodically transmits measurement reports 201 to a BTS 620; conventional measurement reports include parameters such as the transmission BER and RSS. The information contained in the measurement reports 201 is combined with BTS statistics and transmitted in a result report 621 to the BSC 650. In addition, the BSC 650 can receive subscriber class information from the HLR 670 via the MSC 610; subscriber class information may indicate, for example, that a user has subscribed to "premium" service.

In accordance with the principles of the present invention, a subscription to "premium" service may include, for example, a preference for diversity transmission; such preferential service could temporarily exclude network access to other subscribers, if necessary, in order to provide network resources for diversity transmission to the premium subscriber. If the average BER is within an acceptable level, however, it is preferable that diversity transmission not be provided, even for premium subscribers, in order to maximize the availability of system resources.

The present invention provides significant advantages to wireless communications systems, in general, and the invention is particularly advantageous in cellular communications networks. The principles of selective diversity transmission disclosed herein can optimize the transmission quality of cellular communications networks while increasing the utilization of network resources. With the exception of the description of FIGURE 6, in which the transmitter (*i.e.*, TRX 630) is located in a "base station" and the remote receiver is typically "mobile," the foregoing generally described the use of the present invention to improve wireless communications between a "transmitter" and a "remote receiver." A selective diversity transmission scheme according to the principles of the present invention, however, can be employed to improve transmission quality from a base to a mobile receiver *and* from a mobile receiver to a base station. For example, a mobile station (*e.g.*, a "cell phone"), which conventionally includes only one transmitter, could be constructed with a second transmitter having a delay circuit associated therewith, and dual antennas. The second transmitter would preferably not be used, in order to reduce power consumption, but could be dynamically enabled if necessary to

improve the transmission quality of the "r verse" path. Thus, the principles of selectiv diversity transmission disclosed herein can be adapted to all forms of wireless communications systems.

Although the present invention has been described in detail, those skilled in the art will conceive of various changes, substitutions and alterations to the exemplary embodiments described herein without departing from the spirit and scope of the invention in its broadest form. The exemplary embodiments presented herein illustrate the principles of the invention and are not intended to be exhaustive or to limit the invention to the form disclosed; it is intended that the scope of the invention be defined by the claims appended hereto, and their equivalents.

CLAIMS

WHAT IS CLAIMED IS:

1. A wireless communications system for transmitting an input signal to a remote receiver, said wireless communications system comprising:

a first transmitter that receives said input signal and generates a first radio frequency signal;

a second transmitter having a delay associated therewith; and

a diversity transmission mode controller that selectively couples said input signal to said second transmitter as a function of at least one characteristic of said system, said second transmitter generating a second radio frequency signal that is delayed relative to said first radio frequency signal, said remote receiver capable of simultaneously receiving and processing said first and second radio frequency signals whereby the transmission quality of said system is enhanced.

2. The system recited in Claim 1, wherein said characteristic of said system comprises the transmission bit error rate associated with said first radio frequency signal.

3. The system recited in Claim 2, wherein said diversity transmission mode controller couples said input signal to said second transmitter when said transmission bit error rate exceeds a predetermined value.

4. The system recited in Claim 1, wherein said characteristic of said system comprises the received signal strength at said remote receiver associated with said first radio frequency signal.

5. The system recited in Claim 4, wherein said diversity transmission mode controller couples said input signal to said second transmitter when said received signal strength is less than a predetermined value.

6. The system recited in Claim 1, wherein said characteristic of said system comprises a timing advance parameter of said remote receiver.

7. The system recited in Claim 6, wherein said diversity transmission mode controller couples said input signal to said second transmitter when said timing advance parameter equals a predetermined value.

8. The system recited in Claim 1, wherein said characteristic of said system is a function of the number of remote receivers that simultaneous receive service from said system.

9. The system recited in Claim 8, wherein said diversity transmission mode controller couples said input signal to said second transmitter when said number of remote receivers that simultaneous receive service from said system is less than a predetermined value.

10. The system recited in Claim 1, wherein said characteristic of said system comprises a subscriber class of said remote receiver.

11. The system recited in Claim 1, wherein said first and second transmitters comprise a base station.

12. The system recited in Claim 1, wherein said remote receiver comprises a mobile receiver.

13. A method of selectively enabling diversity transmission in a wireless communications system for transmitting an input signal to a remot receiver, said method comprising the steps of:

coupling said input signal to a first transmitter that generates a first radio frequency signal;

determining at least one characteristic of said system; and

coupling said input signal to a second transmitter as a function of said at least one characteristic of said system, said second transmitter generating a second radio frequency signal that is delayed relative to said first radio frequency signal, said remote receiver capable of simultaneously receiving and processing said first and second radio frequency signals whereby the transmission quality of the system is enhanced.

14. The method recited in Claim 13, wherein said characteristic of said system comprises the transmission bit error rate associated with said first radio frequency signal.

15. The method recited in Claim 14, wherein said step of coupling said input signal to a second transmitter comprises the step of coupling said input signal to said second transmitter when said transmission bit error rate exceeds a predetermined value.

16. The method recited in Claim 13, wherein said characteristic of said system comprises the received signal strength at said remote receiver associated with said first radio frequency signal.

17. The method recited in Claim 16, wherein said step of coupling said input signal to a second transmitter comprises the step of coupling said input signal to said second transmitter when said received signal strength is less than a predetermined value.

18. The method recited in Claim 13, wherein said characteristic of said system comprises a timing advance parameter of said remote receiver.

19. The method recited in Claim 18, wherein said step of coupling said input signal to a second transmitter comprises the step of coupling said input signal to said second transmitter when said timing advance parameter equals a predetermined value.

20. The method recited in Claim 13, wherein said characteristic of said system is a function of the number of remote receivers that simultaneous receive service from said system.

21. The method recited in Claim 20, wherein said step of coupling said input signal to a second transmitter comprises the step of coupling said input signal to said second transmitter when said number of remote receivers that simultaneous receive service from said system is less than a predetermined value.

22. The method recited in Claim 13, wherein said characteristic of said system comprises a subscriber class of said remote receiver.

23. The method recited in Claim 13, wherein said first and second transmitters comprise a base station.

24. The method recited in Claim 13, wherein said remote receiver comprises a mobile receiver.

25. A wireless communications n twork for transmitting an input signal to a mobile receiver, said wireless communications network comprising:

a base station, including:

a distribution unit for receiving and distributing a plurality of input signals to at least two transmitters;

a first transmitter, coupled to said distribution unit, that receives one of said plurality of input signals and generates a first radio frequency signal; and

a second transmitter, coupled to said distribution unit, having a delay associated therewith; and

a base station controller that directs said distribution unit to couple said one of said plurality of input signals to said second transmitter as a function of at least one characteristic of said network, said second transmitter generating a second radio frequency signal that is delayed relative to said first radio frequency signal, said mobile receiver capable of simultaneously receiving and processing said first and second radio frequency signals whereby the transmission quality of the network is enhanced.

26. The network recited in Claim 25, wherein said characteristic of said network comprises the transmission bit error rate associated with said first radio frequency signal.

27. The network recited in Claim 26, wherein said base station controller directs said distribution unit to couple said one of said plurality of

input signals to said second transmitter when said transmission bit error rate exceeds a predetermined value.

28. The network recited in Claim 25, wherein said characteristic of said network comprises the received signal strength at said mobile receiver associated with said first radio frequency signal.

29. The network recited in Claim 28, wherein said base station controller directs said distribution unit to couple said one of said plurality of input signals to said second transmitter when said received signal strength is less than a predetermined value.

30. The network recited in Claim 25, wherein said characteristic of said network comprises a timing advance parameter of said mobile receiver.

31. The network recited in Claim 30, wherein said base station controller directs said distribution unit to couple said one of said plurality of input signals to said second transmitter when said timing advance parameter equals a predetermined value.

32. The network recited in Claim 25, wherein said characteristic of said network is a function of the number of mobile receivers that simultaneous receive service from said network.

33. The network recited in Claim 32, wherein said base station controller directs said distribution unit to couple said one of said plurality of input signals to said second transmitter when said number of remote receivers that simultaneous receive service from said network is less than a predetermined value.

34. The network recited in Claim 25, wherein said characteristic of said network comprises a subscriber class of said mobile receiver.

FIG.1 PRIOR ART

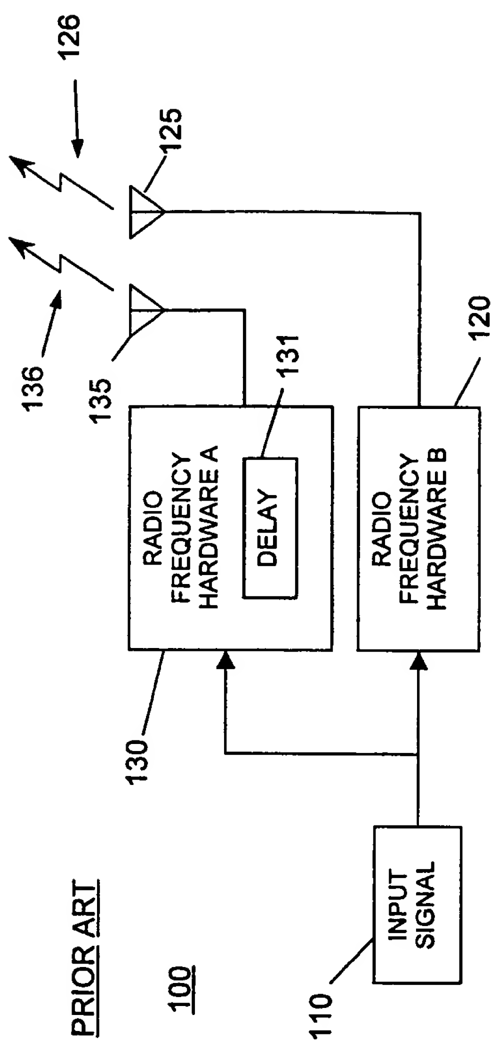


FIG.2 PRIOR ART

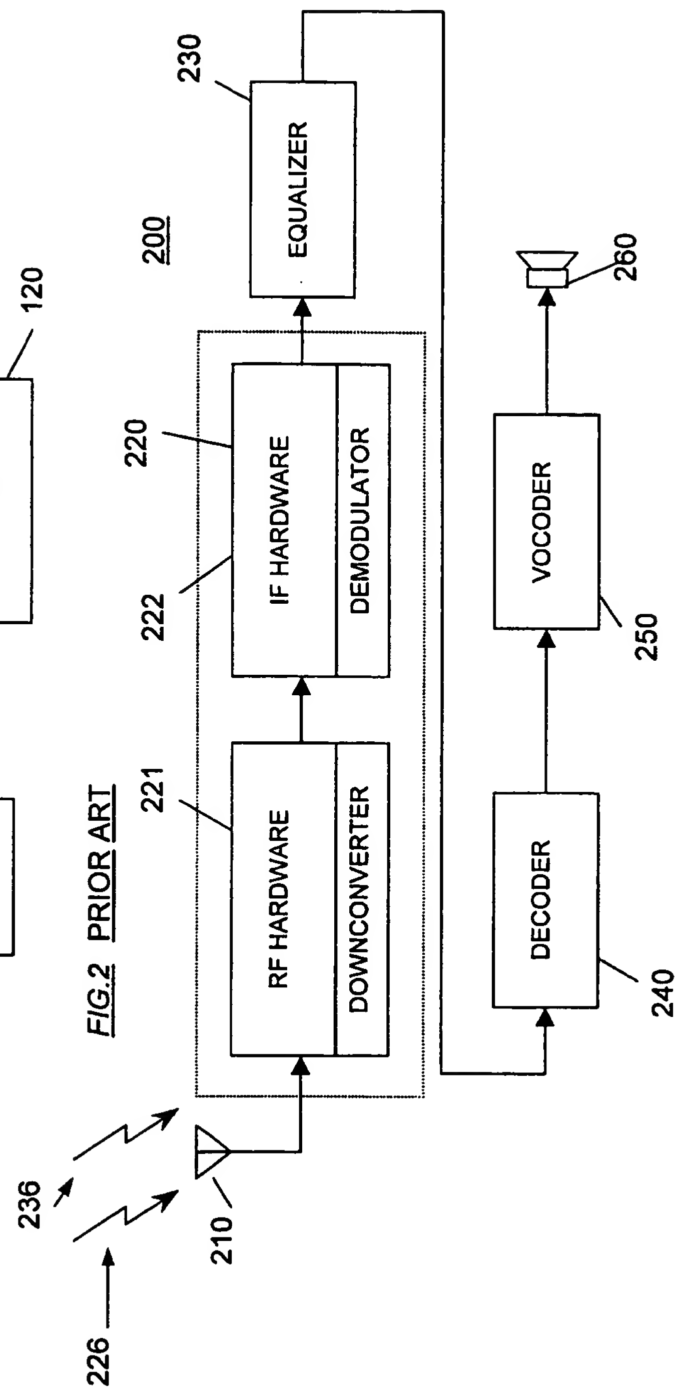
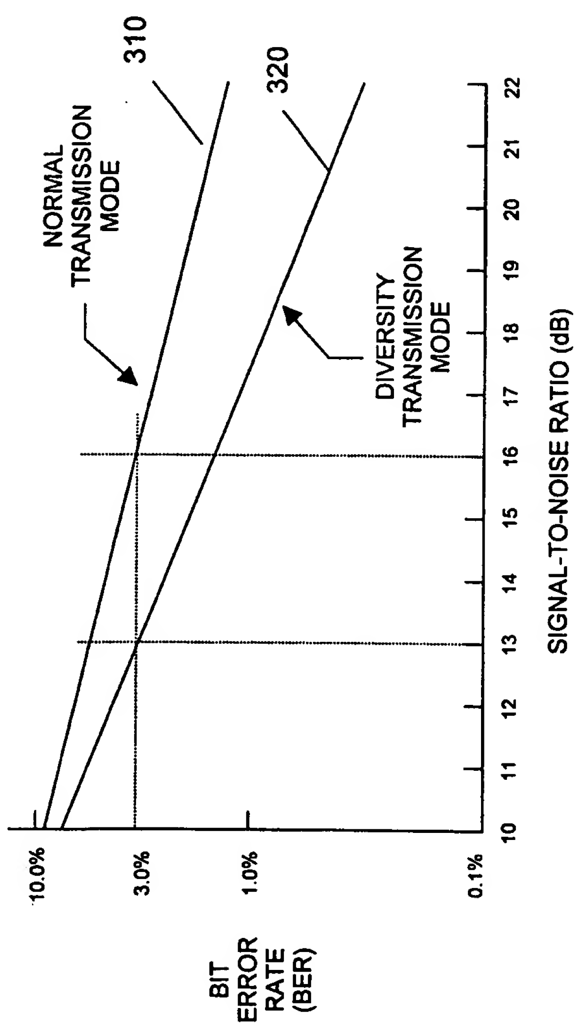


FIG.3


NORMAL TRANSMISSION MODE
310
320
DIVERSITY TRANSMISSION MODE
BIT ERROR RATE (BER)
10.0%
3.0%
1.0%
0.1%
10
11
12
13
14
15
16
17
18
19
20
21
22
SIGNAL-TO-NOISE RATIO (dB)

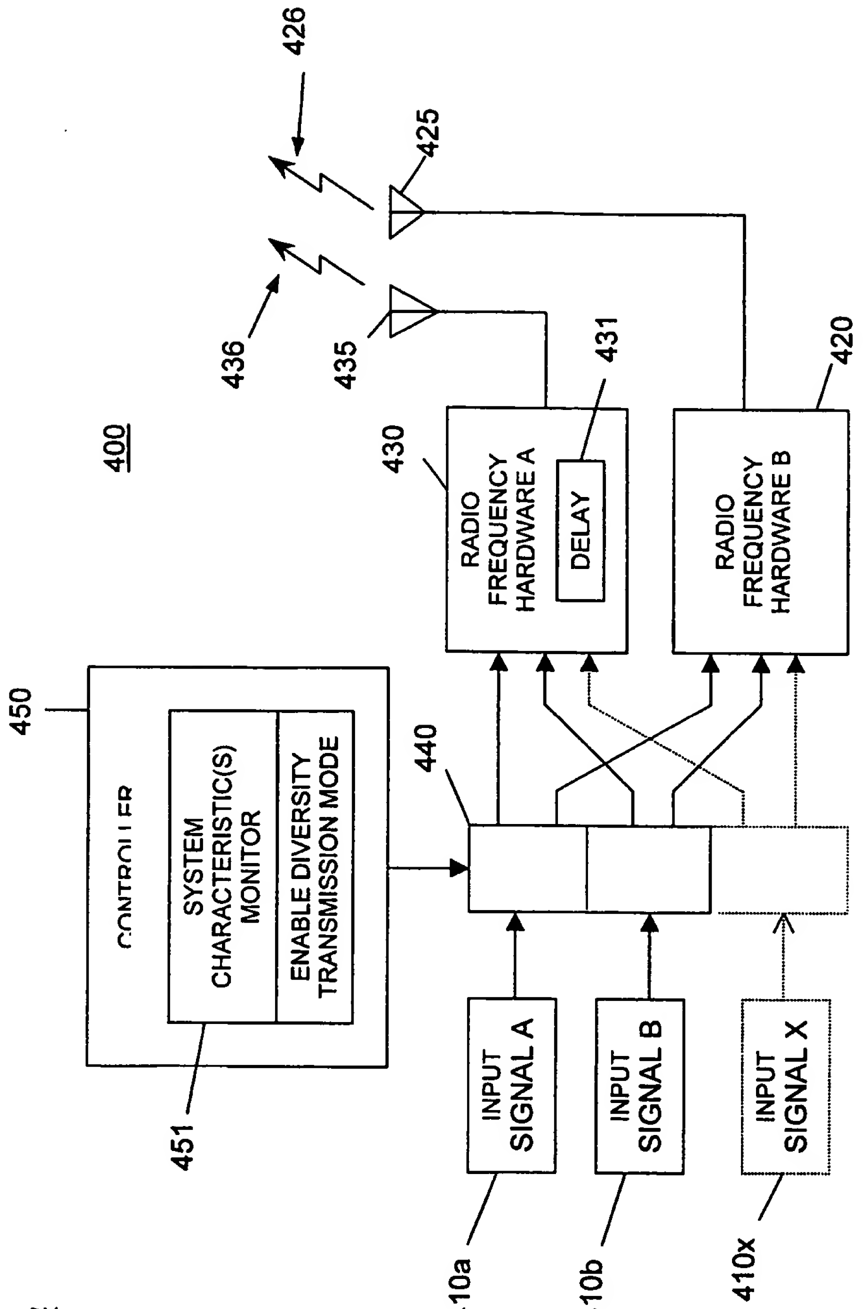
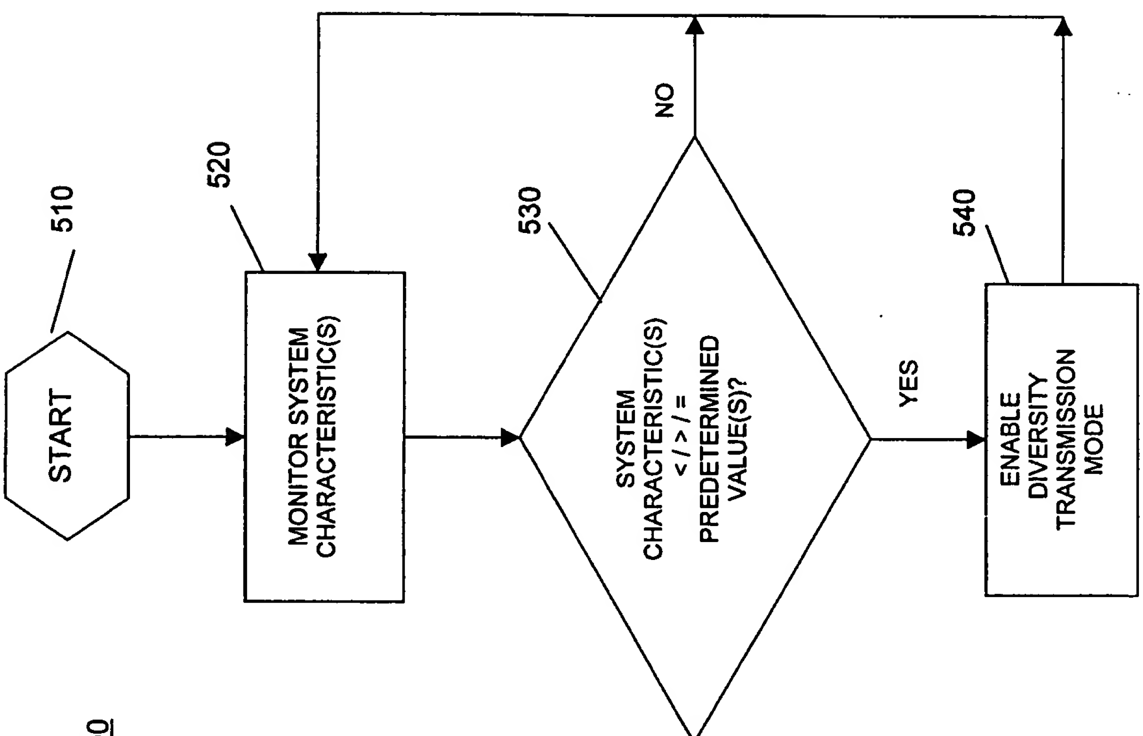

400
426
425
436
435
431
430
420
RADIO FREQUENCY HARDWARE A
DELAY
RADIO FREQUENCY HARDWARE B
450
SYSTEM CHARACTERISTIC(S) MONITOR
ENABLE DIVERSITY TRANSMISSION MODE
440
451
INPUT SIGNAL A
INPUT SIGNAL B
INPUT SIGNAL X
410a
410b
410x

FIG.4

FIG. 5

500


START
510
MONITOR SYSTEM CHARACTERISTIC(S)
520
SYSTEM CHARACTERISTIC(S) < / > / = PREDETERMINED VALUE(S)?
530
NO
YES
ENABLE DIVERSITY TRANSMISSION MODE
540

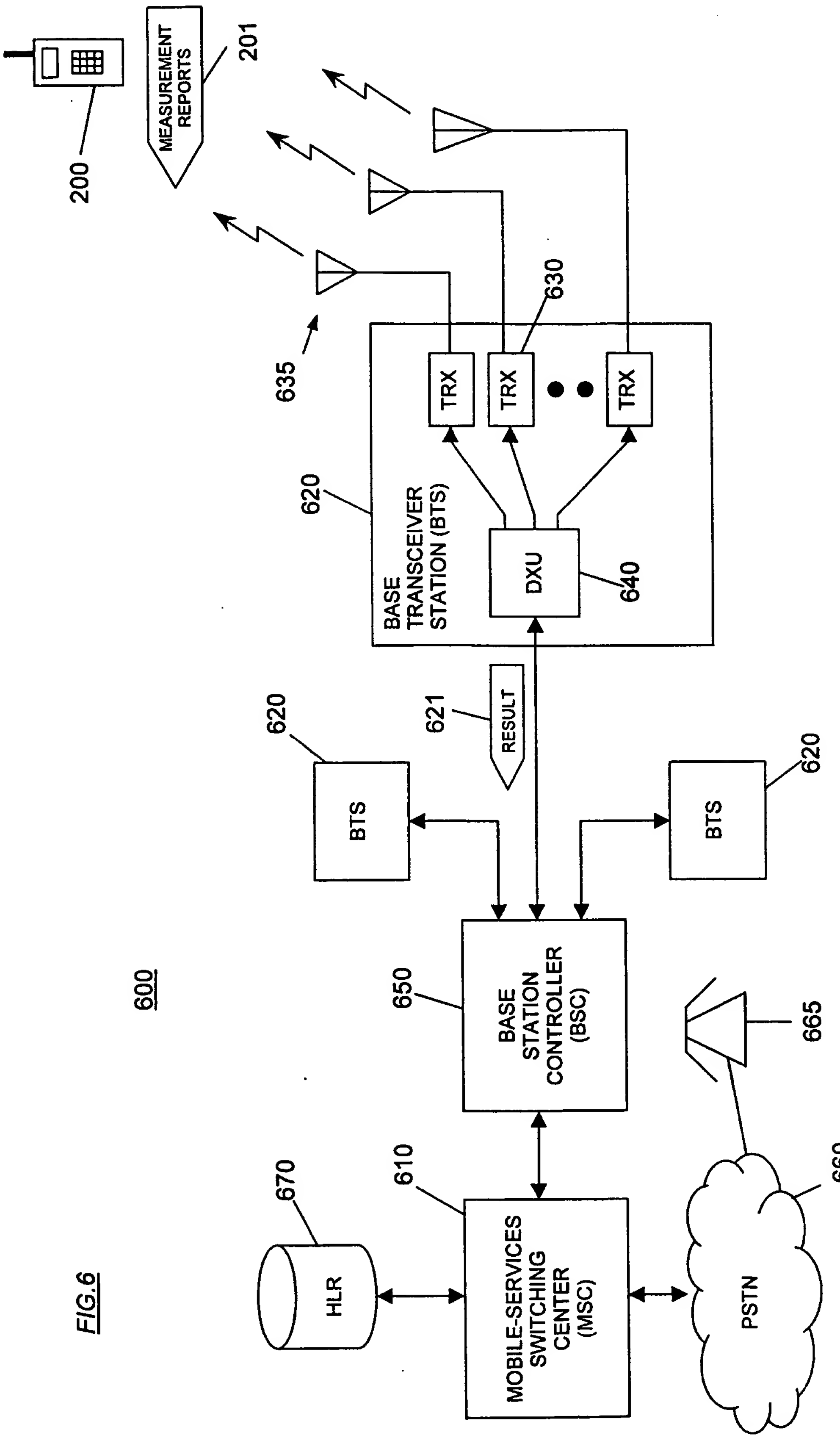

200
MEASUREMENT REPORTS
201
635
630
620
BASE TRANSCEIVER STATION (BTS)
TRX
TRX
TRX
DXU
640
621
RESULT
620
BTS
620
BTS
600
650
BASE STATION CONTROLLER (BSC)
665
670
HLR
610
MOBILE-SERVICES SWITCHING CENTER (MSC)
660
PSTN

FIG.6

INTERNATIONAL SEARCH REPORT

Interr ıal Application No
PCT/US 99/18952

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 542 107 A (KAY STANLEY E) 30 July 1996 (1996-07-30) column 2, line 9 -column 6, line 40 claims 1-5,11-15 figures 1-3,6,7,9 ---	1-5, 11-17, 23-29
A	US 5 345 600 A (DAVIDSON ALLEN L) 6 September 1994 (1994-09-06) abstract column 3, line 42 -column 4, line 30 claims 1,2,4 figure 2 --- -/--	1,13,25

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 1999	22/12/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gkeli, M

3

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/US 99/18952

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 237 706 A (RACAL RES LTD) 8 May 1991 (1991-05-08) page 5, line 10 -page 7, line 4 page 9, line 14 -page 10, line 8 figures 1,3,4 -----	1,13,25

3

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interr ...al Application No
PCT/US 99/18952

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US 5345600 A	06-09-1994	CN 1128590 A,B	07-08-1996
		EP 0720792 A	10-07-1996
		JP 9502065 T	25-02-1997
		WO 9506981 A	09-03-1995
GB 2237706 A	08-05-1991	NONE	